

# HPDA Training

## Data Visualization using ParaView

Niklas Röber, Michael Böttinger,  
Karin Meier Fleischer, Dela Spickermann, Florian Ziemer  
Deutsches Klimarechenzentrum (DKRZ)

- 06.10.2020** – **Data Analytics by Donatello & Fabricio (CMCC)**  
Introduction to HPDA, eScience, and Ophidia HPDA framework  
Hands-on: notebooks with PyOphidia
- 13.10.2020** – **Data Visualization by Florian & Niklas (DKRZ)**  
Overview of Data Visualization, Introduction to ParaView  
Hands-on: ParaView
- 20.10.2020** – **Data Analytics by Donatello & Fabricio (CMCC)**  
Ophidia advanced concepts  
Hands-on: notebooks with PyOphidia
- 27.10.2020** – **Data Visualization by Florian & Niklas (DKRZ)**  
Advanced Data Visualization, Linking Views, Other Models, WRF  
Hands-on: ParaView

# Session Organization

- Please mute your mic and switch off your webcam. The talk will be recorded and published online. If you don't want to be recorded, please leave your camera and microphone always switched off.
- Please post questions and comments in the google doc  
[docs.google.com/document/d/1QXlhAFAF7HF6ptTvrIJ4KDPd8Fb4d3GmS059fOEb3DA](https://docs.google.com/document/d/1QXlhAFAF7HF6ptTvrIJ4KDPd8Fb4d3GmS059fOEb3DA)
- A virtual machine for the hands-on has been made available at:  
[download.ophidia.cmcc.it/vmi\\_desktop/HPDA\\_Vis\\_Training/HPDAVisTrainingVMI.ova](https://download.ophidia.cmcc.it/vmi_desktop/HPDA_Vis_Training/HPDAVisTrainingVMI.ova)

# Visualization Workshops at DKRZ


- Hands-on tutorials for ParaView, NCL, VaPOR from 2 and 5 days
- Some online tutorials available at [www.dkrz.de/up/services/analysis](http://www.dkrz.de/up/services/analysis)
- Online video tutorials coming soon
- ESiWACE2: dedicated data analytics and visualization workshop



## Documentation

[How to get a user account](#)[Mistral](#)[HPSS tape archive](#)[Data Processing](#)[Visualization](#)[Software](#)[Avizo Green](#)[Avizo Earth](#)[Paraview](#)[Simvis](#)[Vapor](#)[NCL](#)[PyNGL / PyNIO](#)[Python matplotlib](#)[GrADS](#)[CUDA](#)[Visualization on](#)[Mistral](#)[Remote3D](#)[Filesystems](#)[Cloud Storage](#)[Training](#)[FAQs & known issues](#)[Seminar Rooms](#)[IMDI](#)[Terms of use](#)


## News

 **New supercomputer „Mistral“ at DKRZ delivers particularly detailed regional climate simulations for Germany**


Oct 05, 2015

 **Preview: DKRZ at SC<sup>15</sup>**

Sep 30, 2015

 **Kick-off for ESIWACE and ESCAPE**

Sep 29, 2015

 **Allocations 2016 - request resources**

[Home](#) → [User Portal](#) → [Documentation](#) → [Visualization](#) → [Software](#) → [Paraview](#)

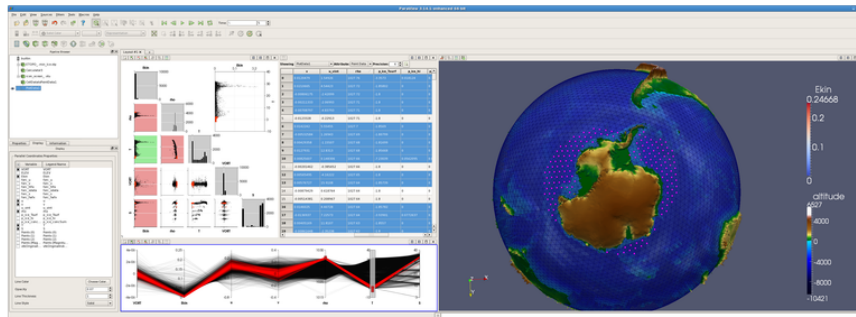
## ParaView

**Paraview is an open source visualization package that reads a variety of different data formats and lattices and implements the most common visualization techniques. More specifically, Paraview also reads netCDF files and supports different grids, so that it can be used to visualize climate and earth science data sets.**

Paraview 4.1 is installed on all visualization nodes of Halo and can be started from the command line via 'paraview'. Older versions of Paraview can be started by appending the version number, such as 'paraview3.98'.

Paraview has come a long way and is used and developed by a very large community from a variety of different sciences. It is installed on DKRZ's Halo nodes since the end of 2012, and we have now prepared a little tutorial that will teach you how to use Paraview for the visualization of your own climate research data.

More general information on Paraview, along with some tutorial data can also be found online on the [Paraview website](#).



The above example shows a complex visualization of an ICON ocean data set using Paraview. The viewport on the right displays the data, the selection made, as well as the Earth's topography. The three viewports on the left hand side are used to specify the selection, based on a scatterplot matrix and parallel coordinates. These techniques are especially well suited for an in-depth data analysis and exploration.

## Paraview Tutorial

The final tutorial document will comprise 8 chapters and will be released at the end of the summer in 2014. Alongside, we will provide courses to teach Paraview in a hands-on setting. The first course will already start in December 2013.

Here is a glimpse of the content from the tutorial:

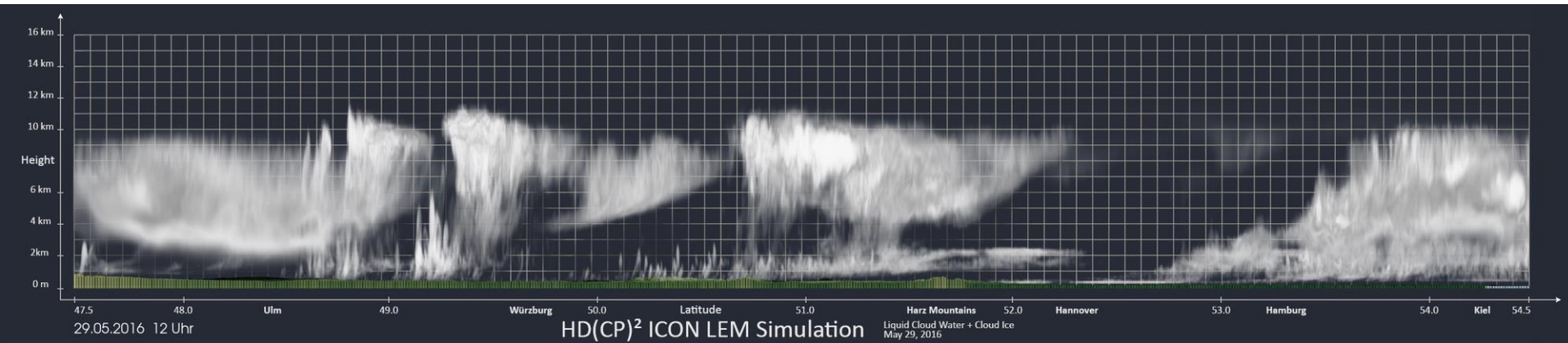
- Chapter 1 "Introduction and Overview" --- The first Chapter starts with an overview of Paraview and briefly explains the underlying visualization toolkit pipeline. The second part of this chapter concentrates on an introduction of the user interface, some data preparation tasks, and creates a first simple visualization, supported using an ECMWF

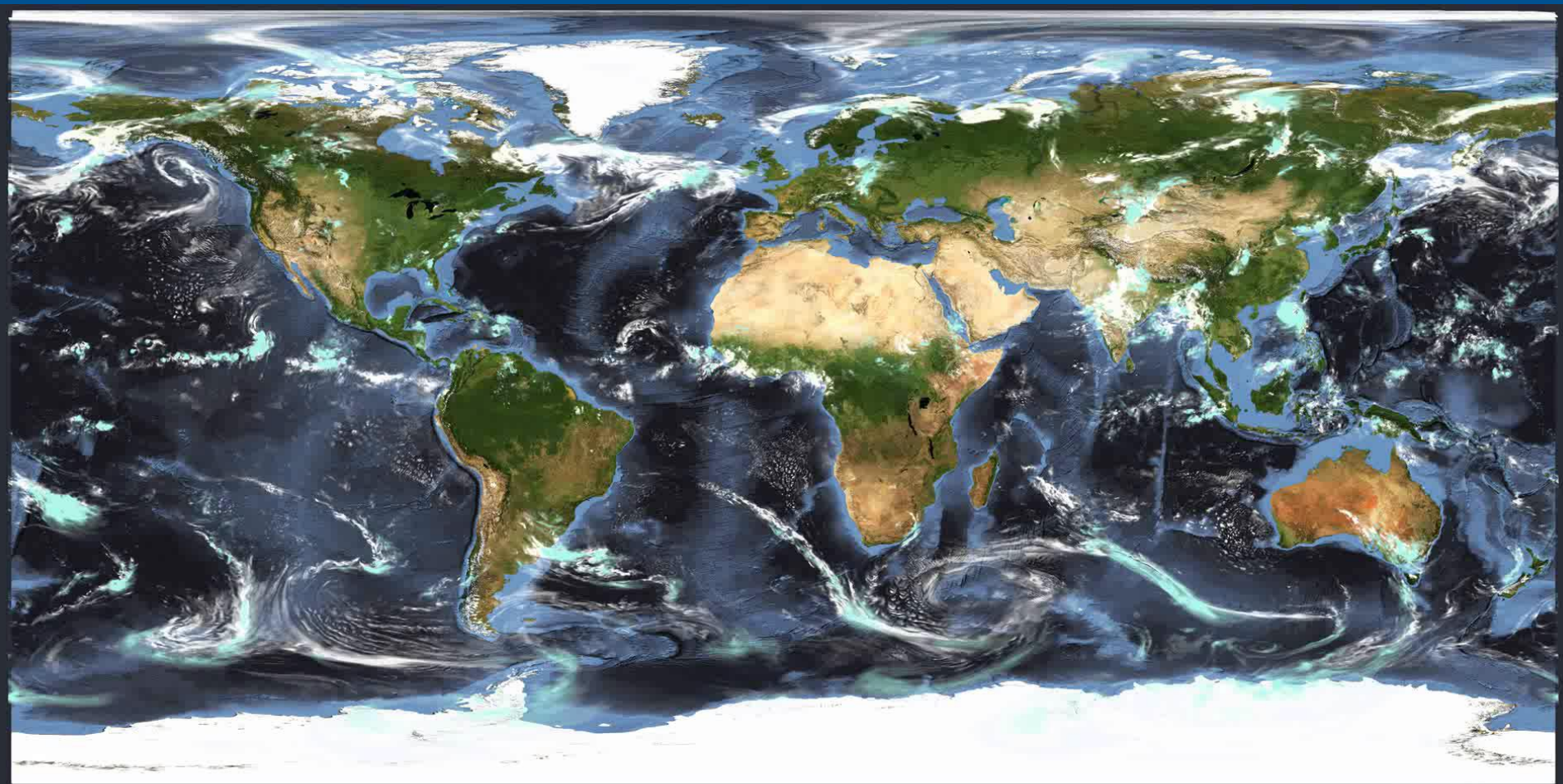
# Visualization Work at DKRZ

- Looking at ways to work and interact with LARGE data
  - In-situ visualization with ParaView/Catalyst
  - Compression and progressive data visualization using wavelets and Vapor
  - Batch visualization on MISTRAL using ParaView and NCL
- Compression, especially *lossy*, as it has always been done (precision, variables, temporal/spatial resolution, model error, GRIB)
- Visualization of uncertainty
- Multivariate data visualization
- Machine learning & online feature tracking

*See, understand, learn, communicate ...*

- **Confirmatory** visualization
- **Exploratory** visualization
- Creating animations & stills for **communication**

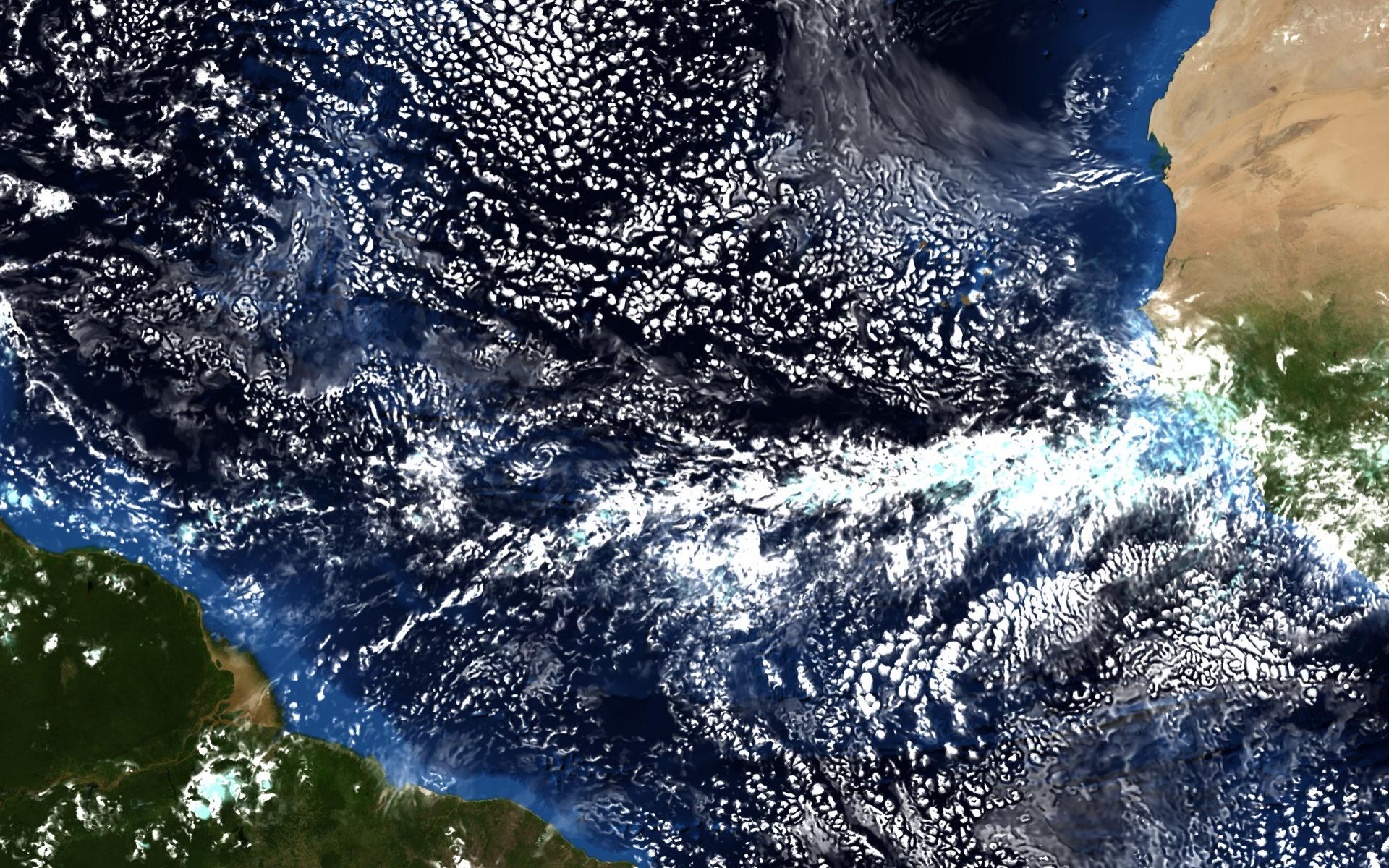


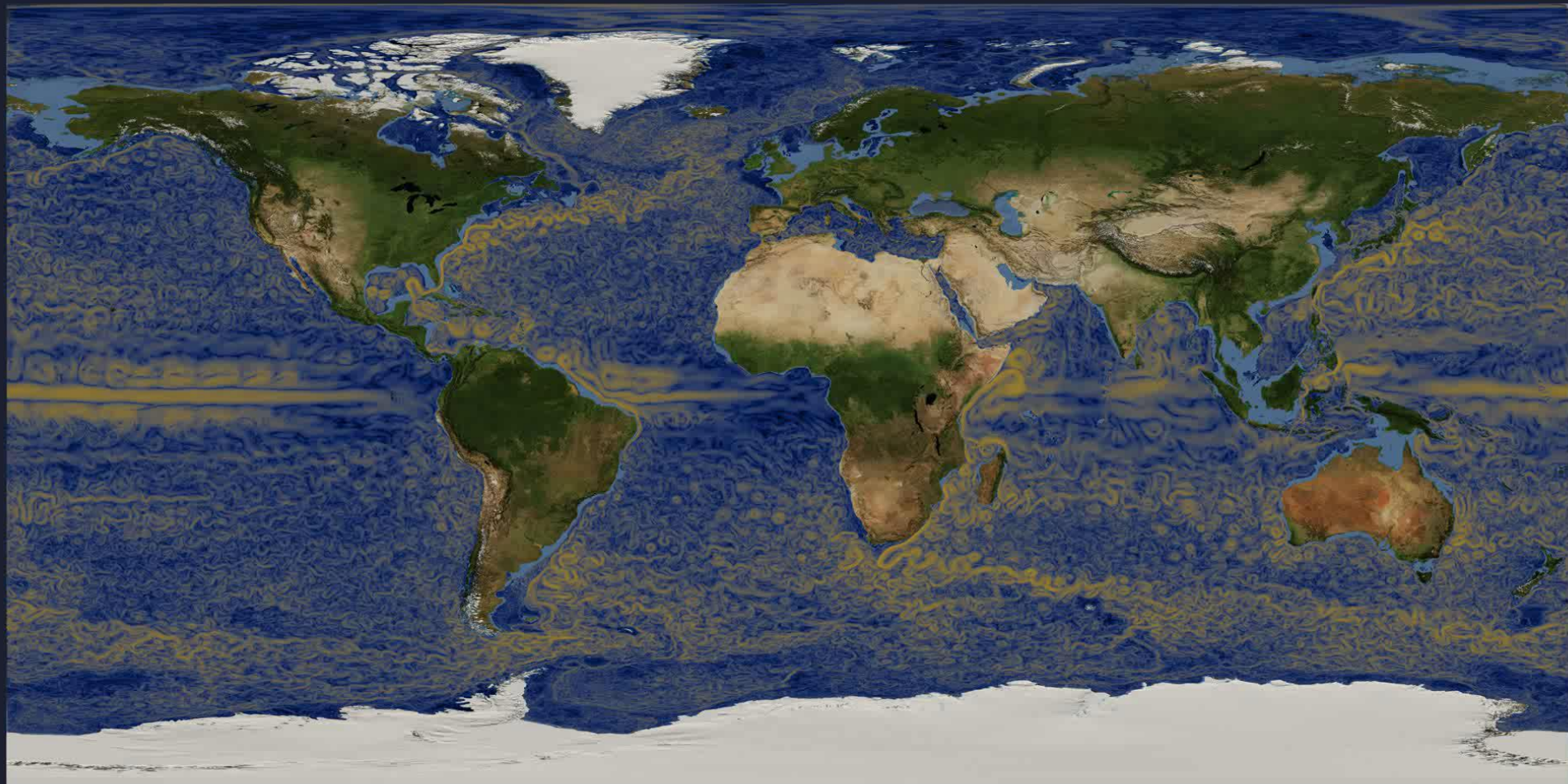


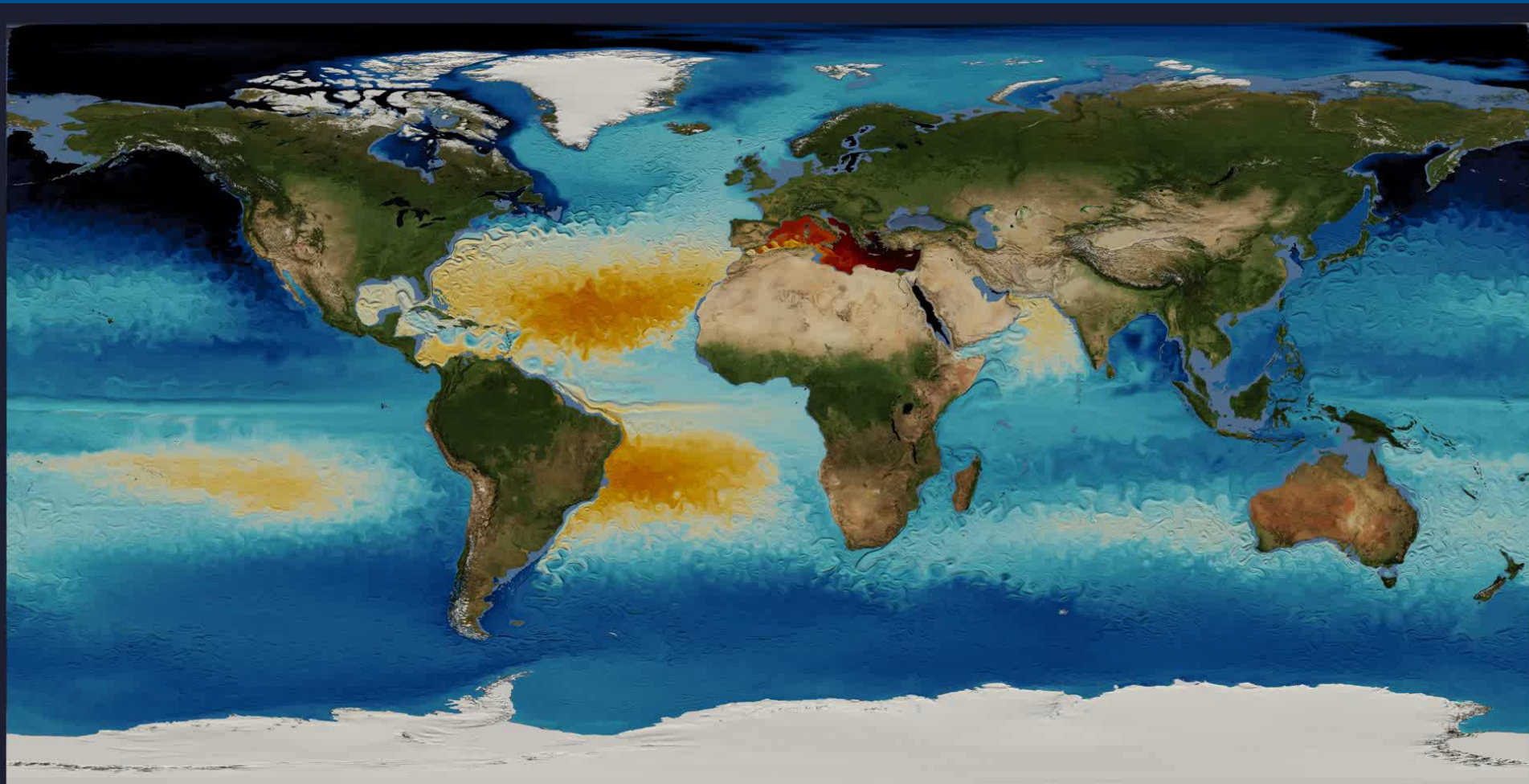
ICON DYAMOND R2B10 2.5km Resolution  
01.08.2016 at 00:00

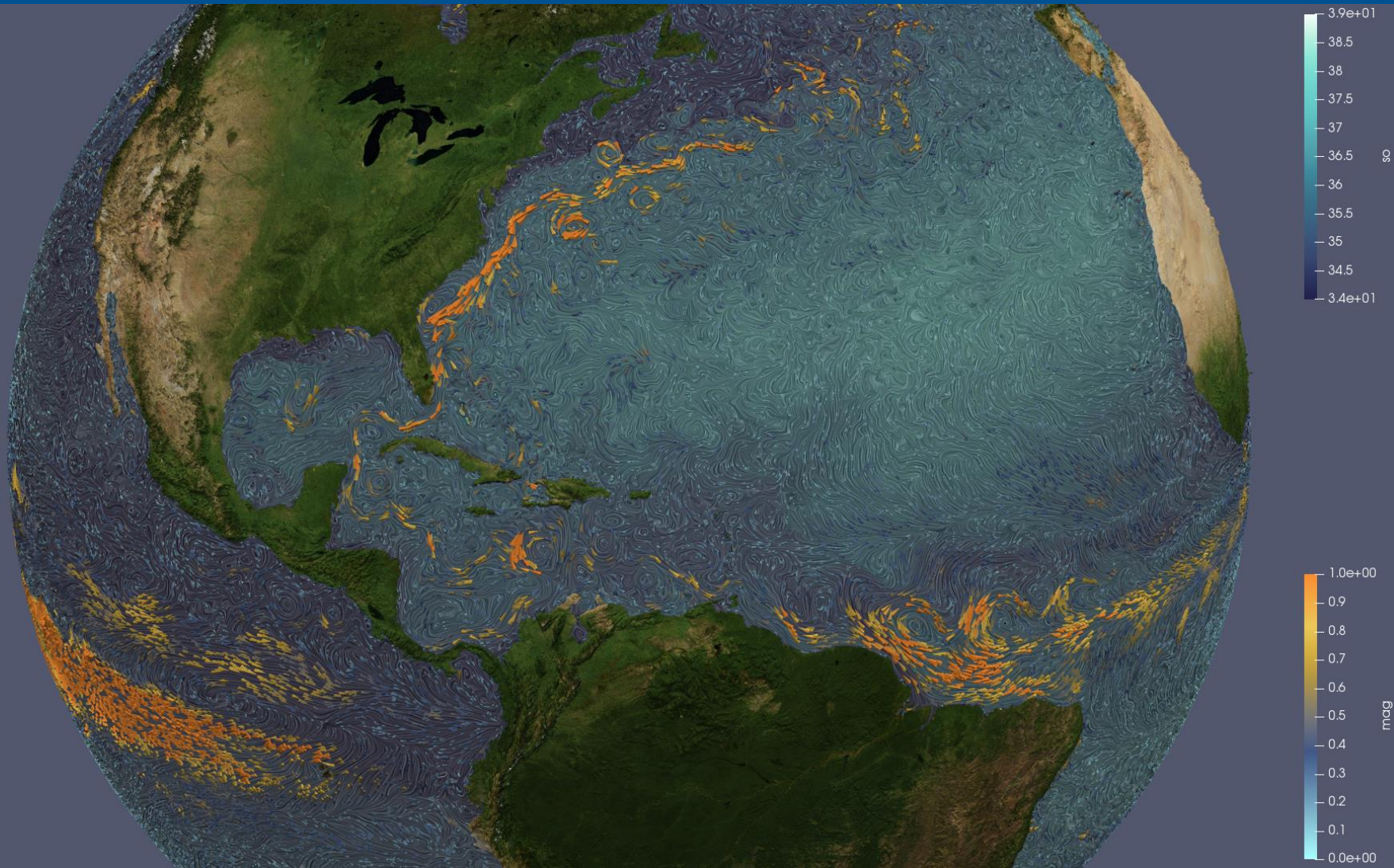




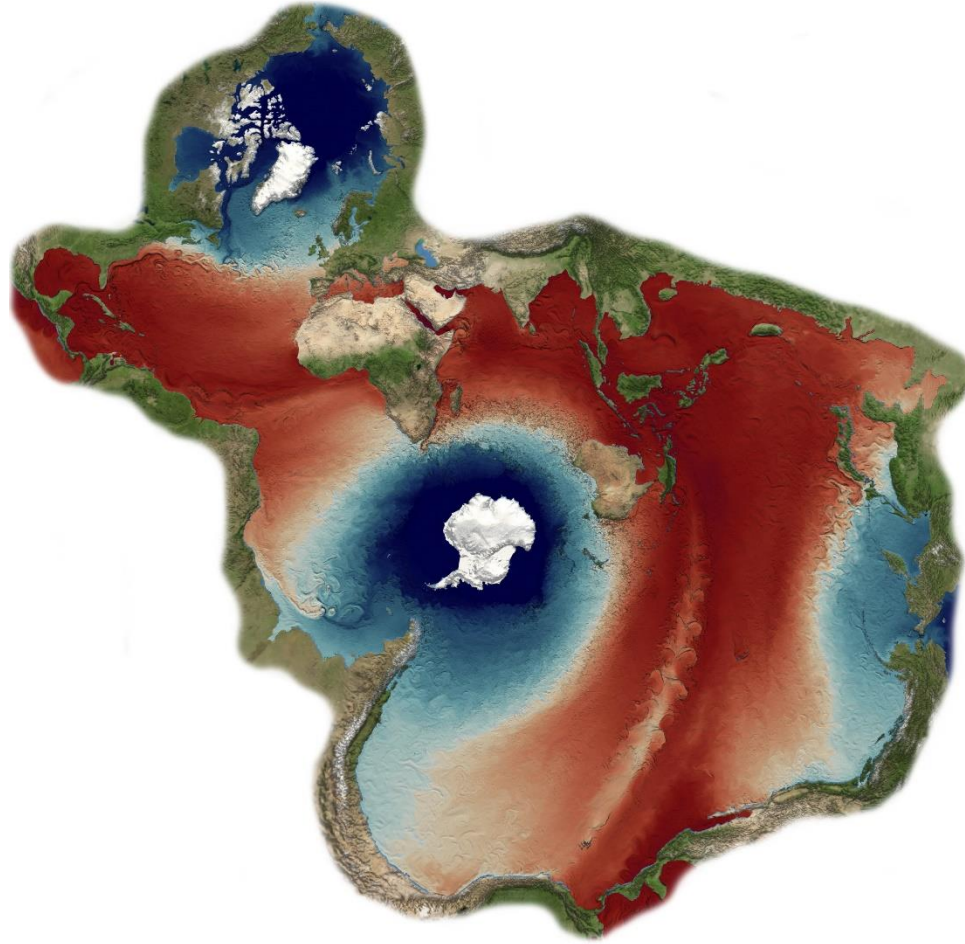


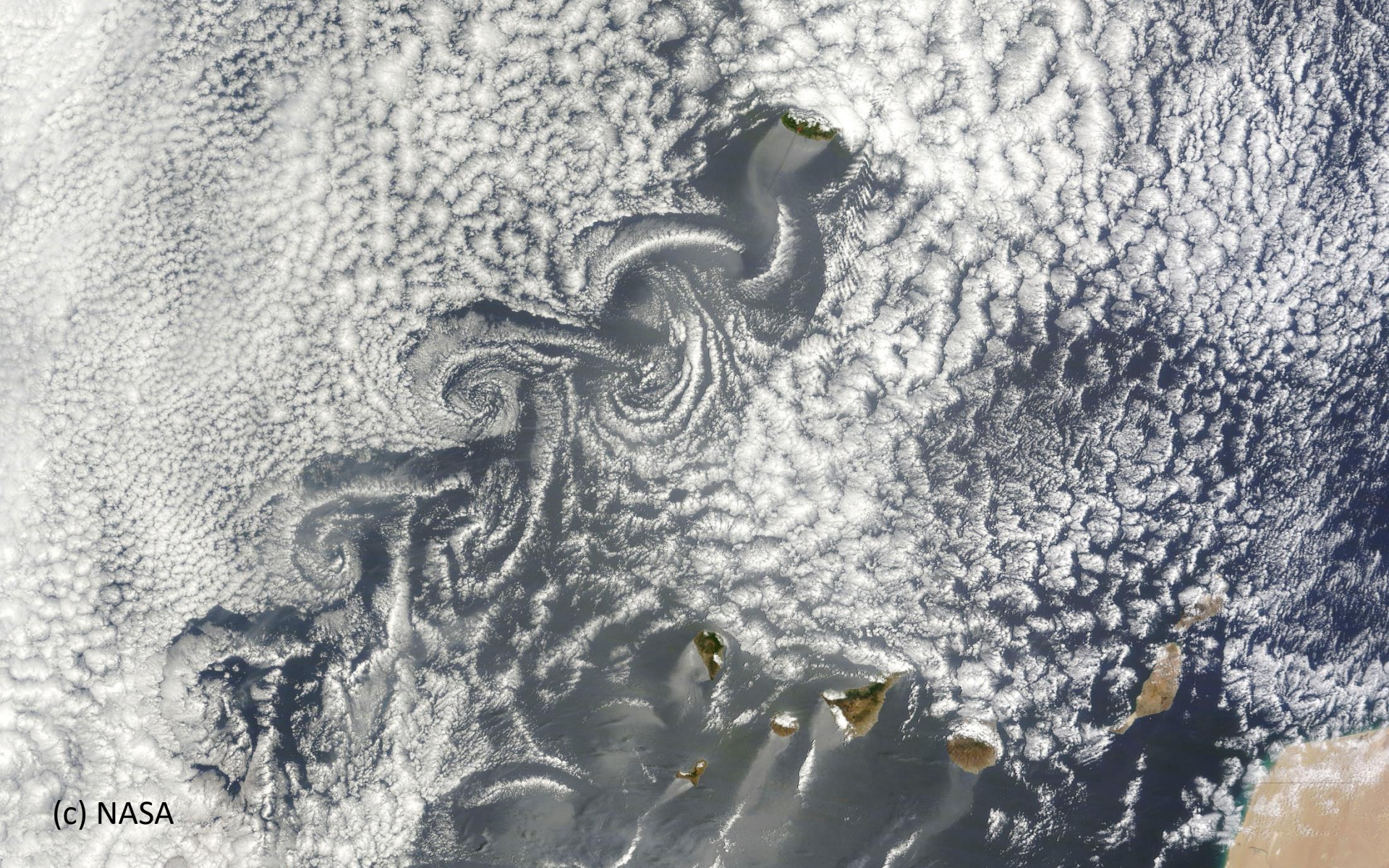






# The Spilhaus Projection





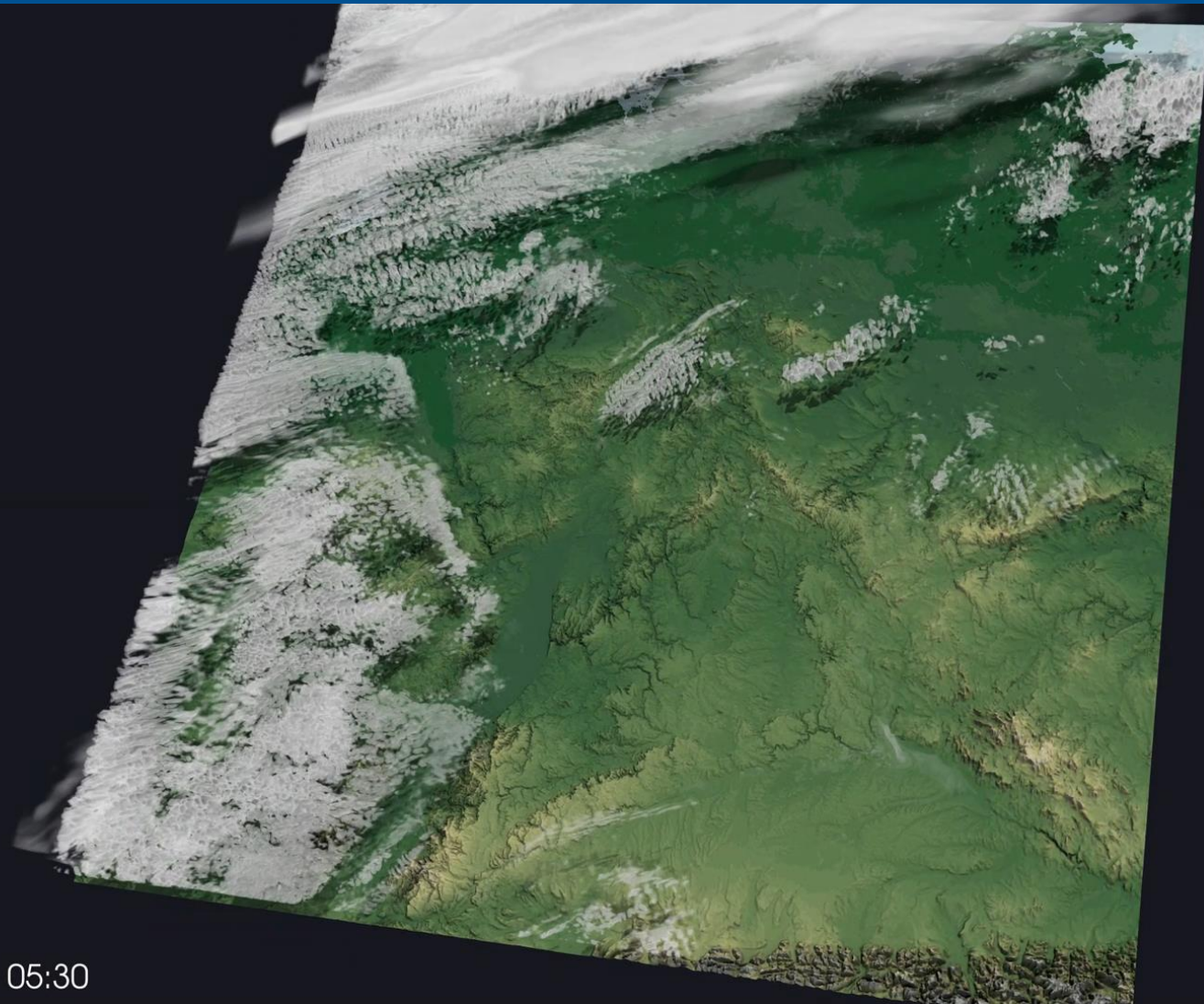
(c) NASA

# Canary Islands

DYAMOND R2B10 - 2D Wind Visualization  
(3 Minute Output - 10m Height)





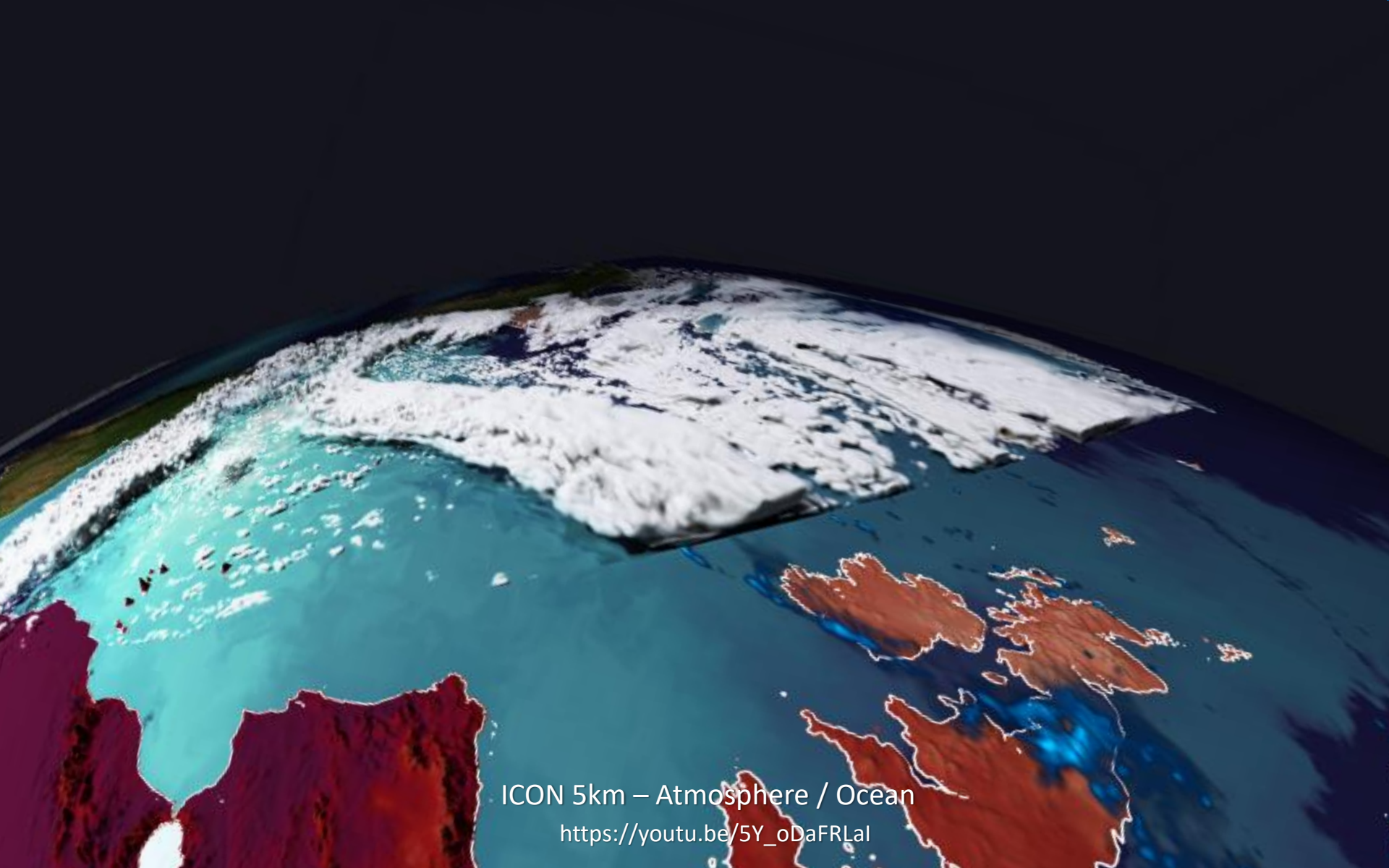


26.04.2013 05:30

Niklas Röber (DKRZ)

18.12.2020

17

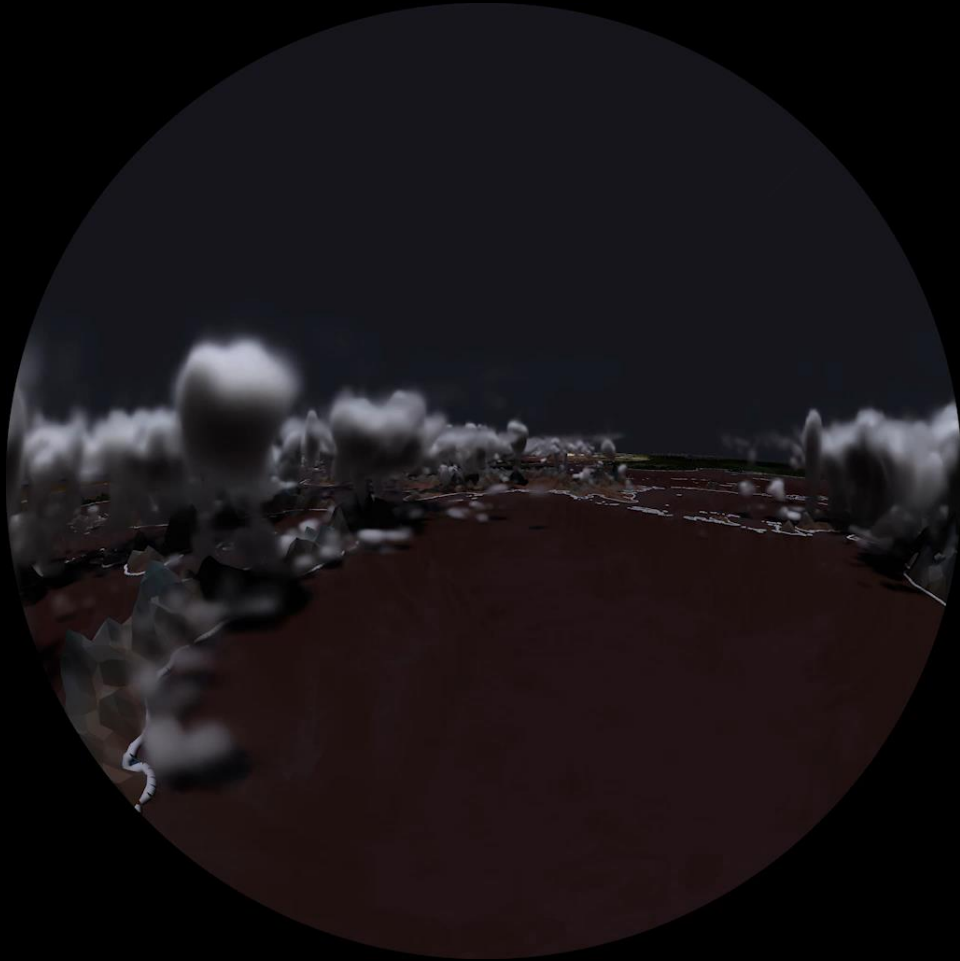
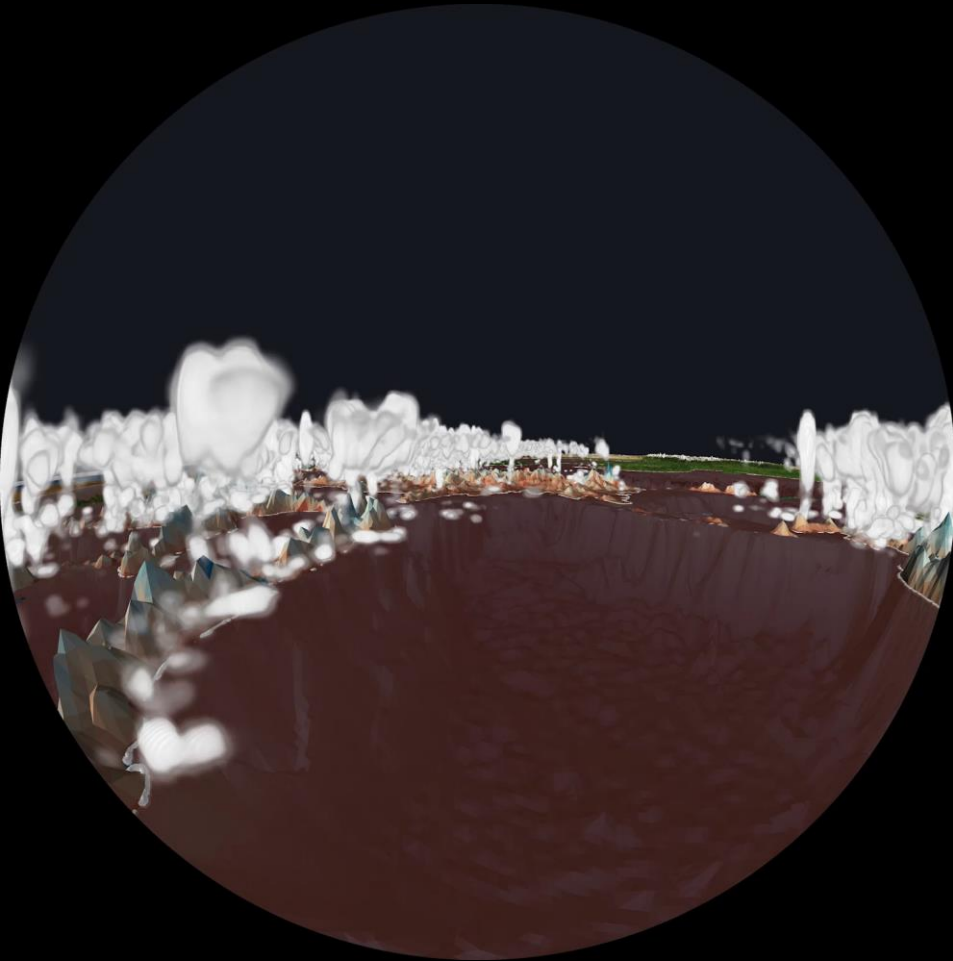


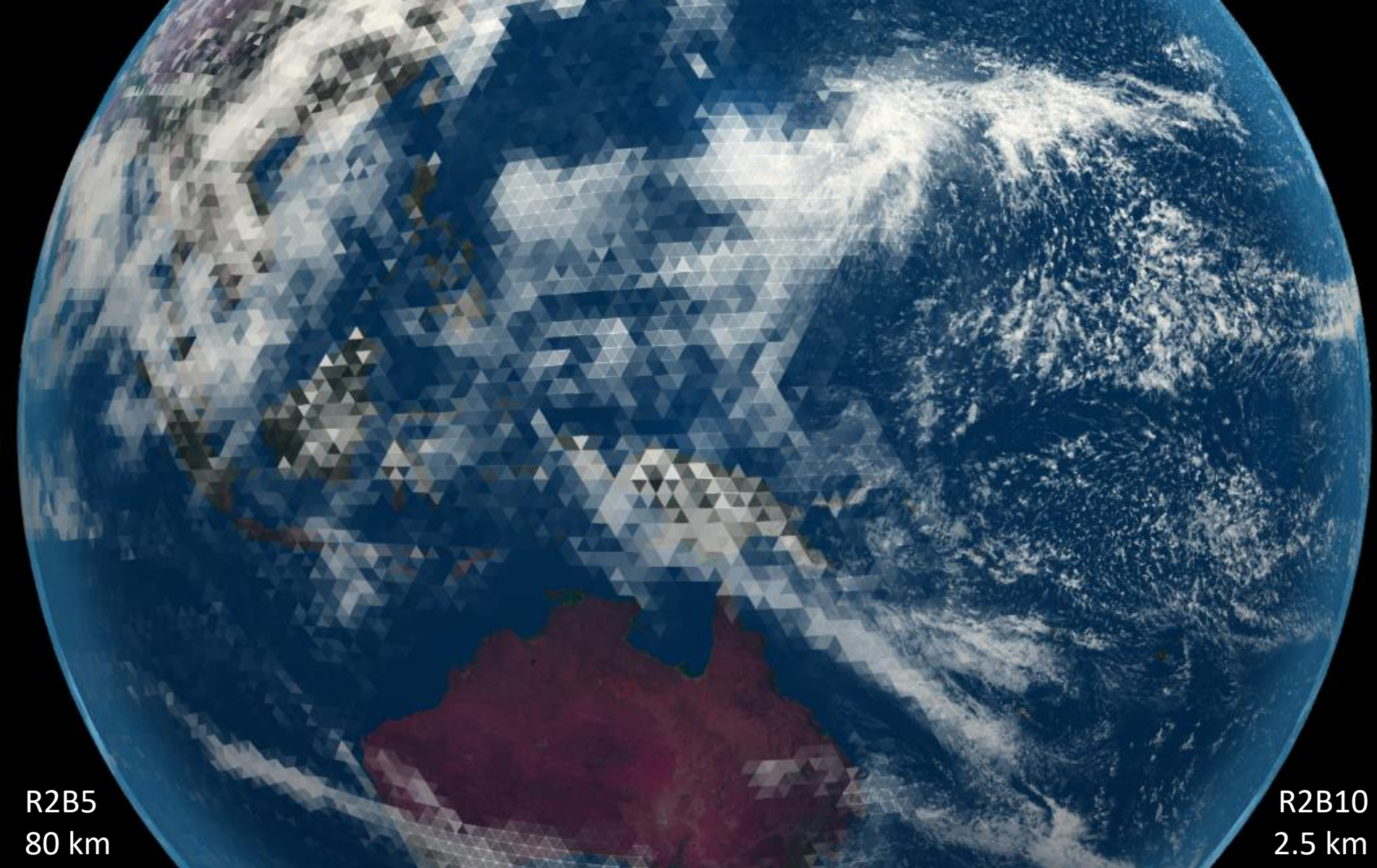
ICON 5km – Atmosphere / Ocean

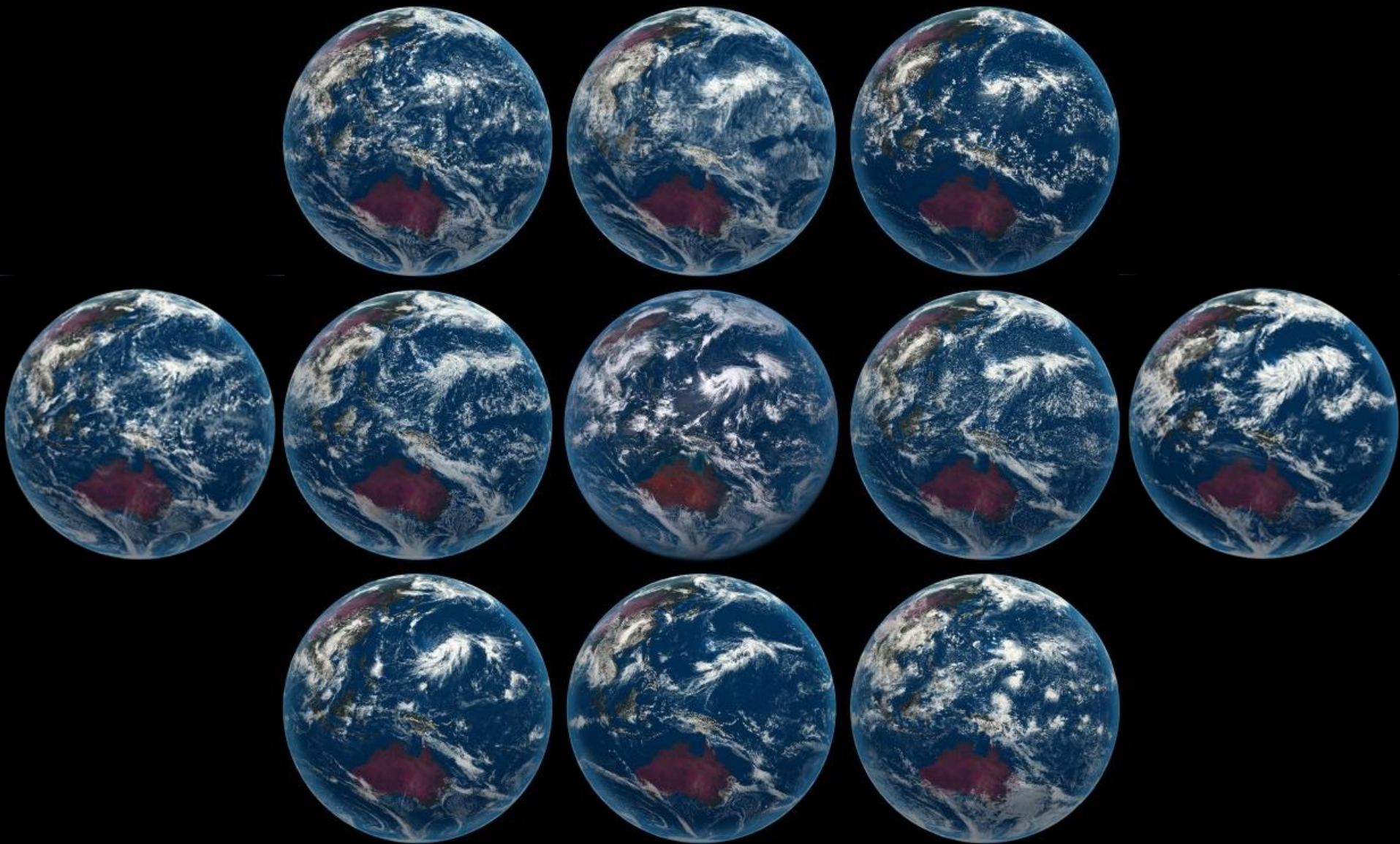
[https://youtu.be/5Y\\_oDaFRLal](https://youtu.be/5Y_oDaFRLal)

# OpenGL

# OSPRay

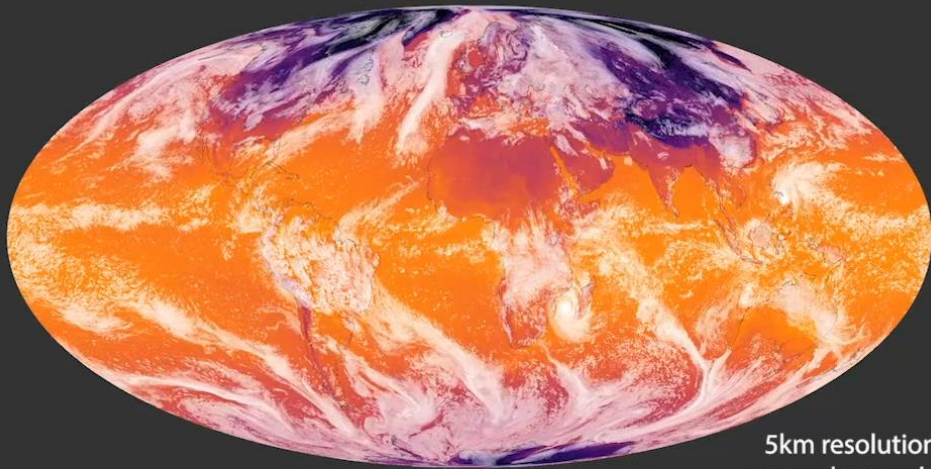




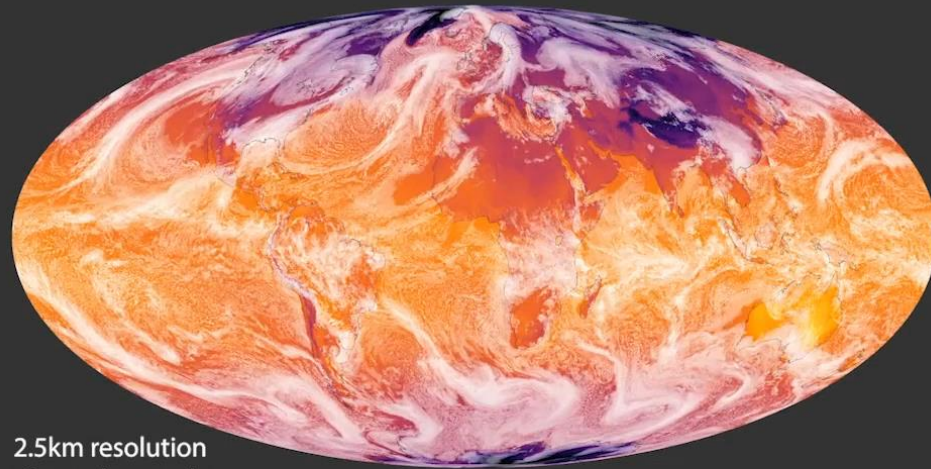


2020-02-04 00:00 UTC

2020-02-04 00:15 UTC

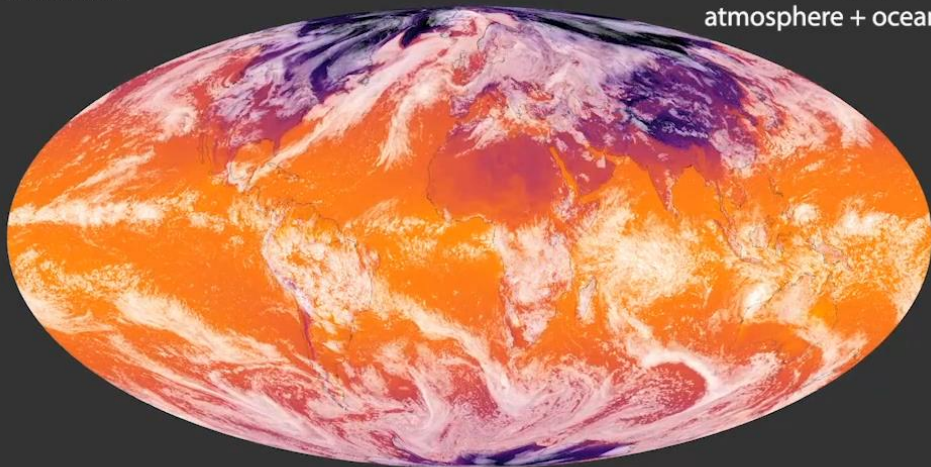


5km resolution  
atmosphere only

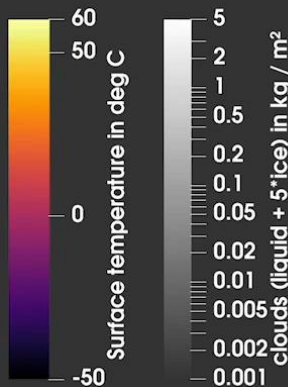


2.5km resolution  
atmosphere only

2020-02-04 00:00 UTC



5km resolution  
atmosphere + ocean



esiwace  
CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER  
AND CLIMATE IN EUROPE



DKRZ



Max-Planck-Institut  
für Meteorologie

DWD

Deutscher Wetterdienst  
Wetter und Klima aus einer Hand



Hans-Ertel-Zentrum  
für Wetterforschung

ESiWACE2 has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 823988



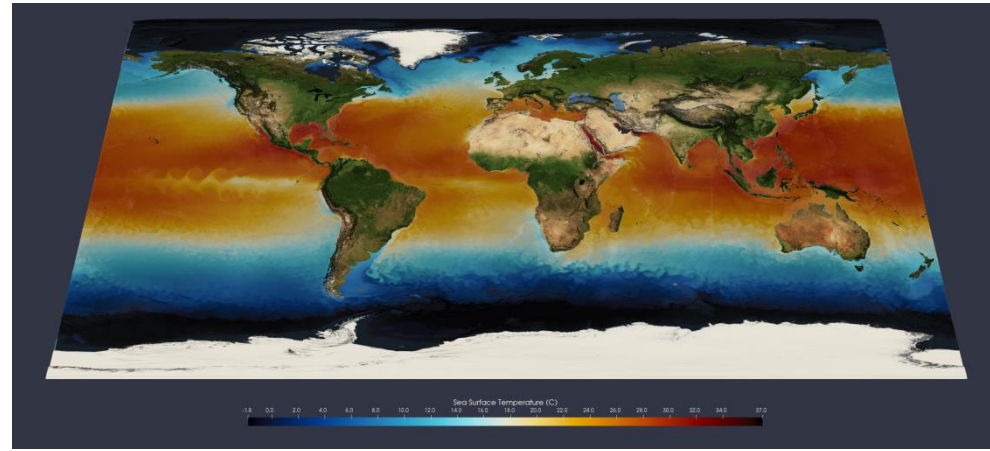
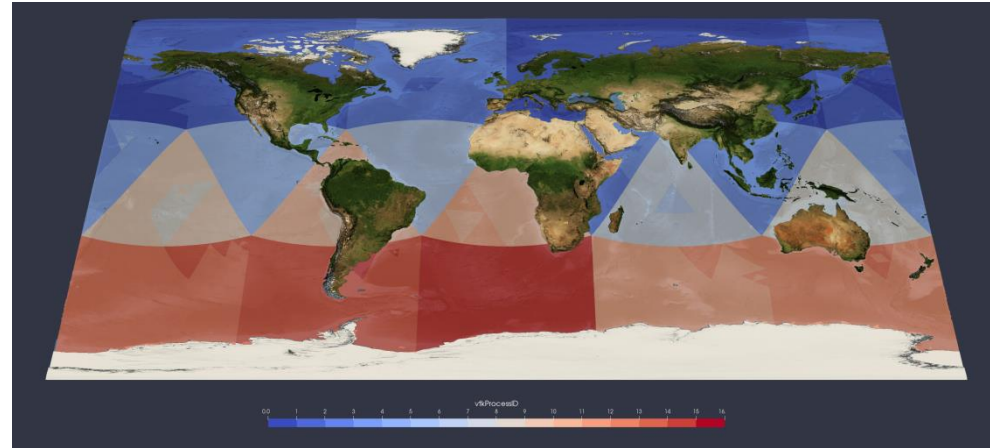
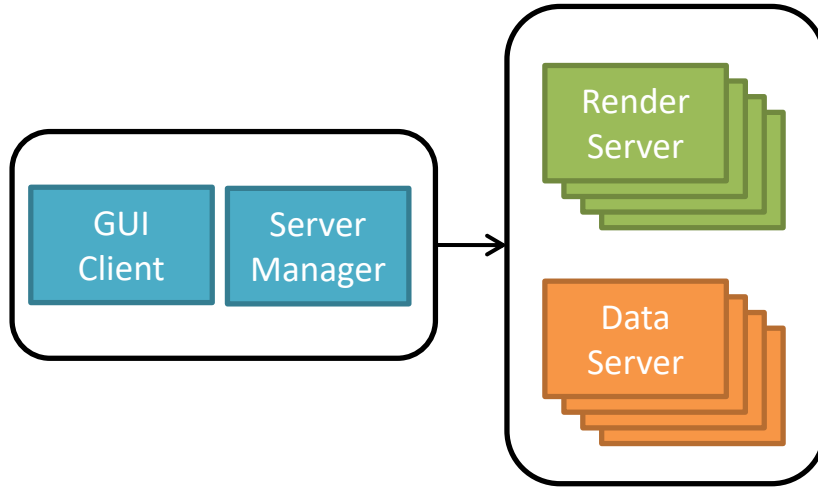
- 21 GPU nodes (two Haswell/Boadwell, 256/512/1024 GB memory)
- 4 GPUs per node (two dual Kepler/Maxwell)
- Software: NCL, ParaView, VaPOR, IDL, Python

# Visualization Software on Mistral

Type	Name	URL	Properties	
Domain-specific	<b>NCL</b>	<a href="http://www.ncl.ucar.edu/">http://www.ncl.ucar.edu/</a>	2D script-based	free
	IDV	<a href="http://www.unidata.ucar.edu/software/idv/">http://www.unidata.ucar.edu/software/idv/</a>	2D/3D interactive GUI	free
	<b>Vapor</b>	<a href="https://www.vapor.ucar.edu/">https://www.vapor.ucar.edu/</a>	3D interactive GUI	free
	UV-CDAT	<a href="http://uvcdat.llnl.gov/">http://uvcdat.llnl.gov/</a>	Collection: 2D /3D tools	free
	GrADS	<a href="http://cola.gmu.edu/grads/">http://cola.gmu.edu/grads/</a>	2D script-based	free
	GMT	<a href="http://gmt.soest.hawaii.edu/">http://gmt.soest.hawaii.edu/</a>	2D script-based	free
	<b>PyNGL / PyNIO</b>	<a href="https://www.pyngl.ucar.edu/Download/">https://www.pyngl.ucar.edu/Download/</a>	2D script-based	free
General-purpose	<b>ParaView</b>	<a href="http://www.paraview.org/">http://www.paraview.org/</a>	3D interactive GUI	free
	Visit	<a href="https://visit.llnl.gov/">https://visit.llnl.gov/</a>	3D interactive GUI	free
	Avizo	<a href="https://www.fei.com/software/avizo3d/">https://www.fei.com/software/avizo3d/</a>	3D interactive GUI	\$\$
	<b>IDL</b>	<a href="http://www.harrisgeospatial.com/">http://www.harrisgeospatial.com/</a>	2D script-based	\$\$
	<b>Python / matplotlib</b>	<a href="http://matplotlib.org/">http://matplotlib.org/</a>	2D script-based	free

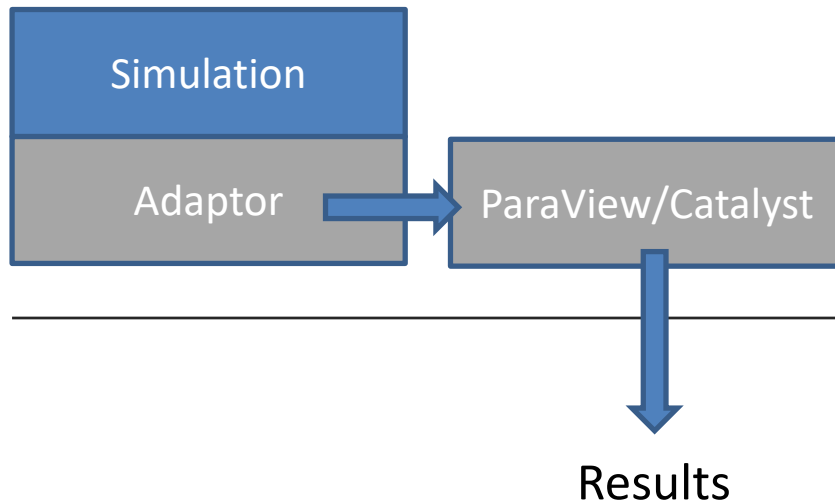


# Parallel Processing and Visualization

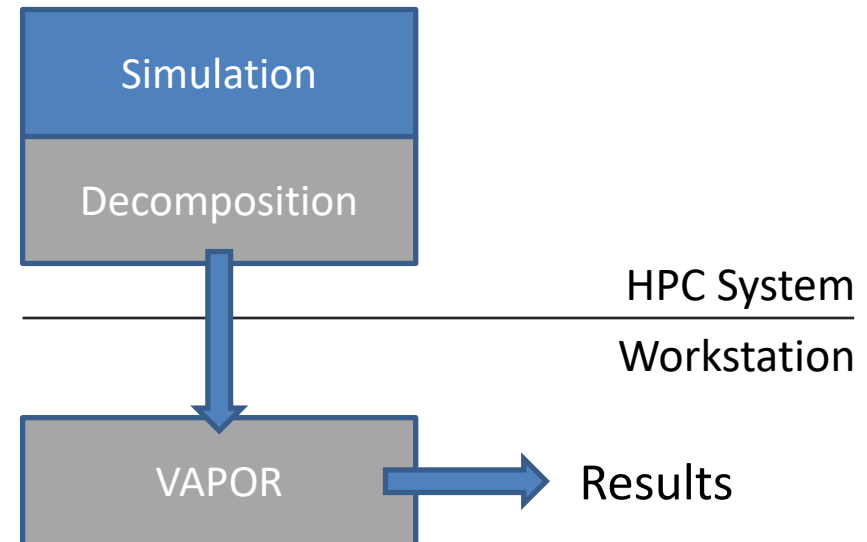


# Large Data Visualization

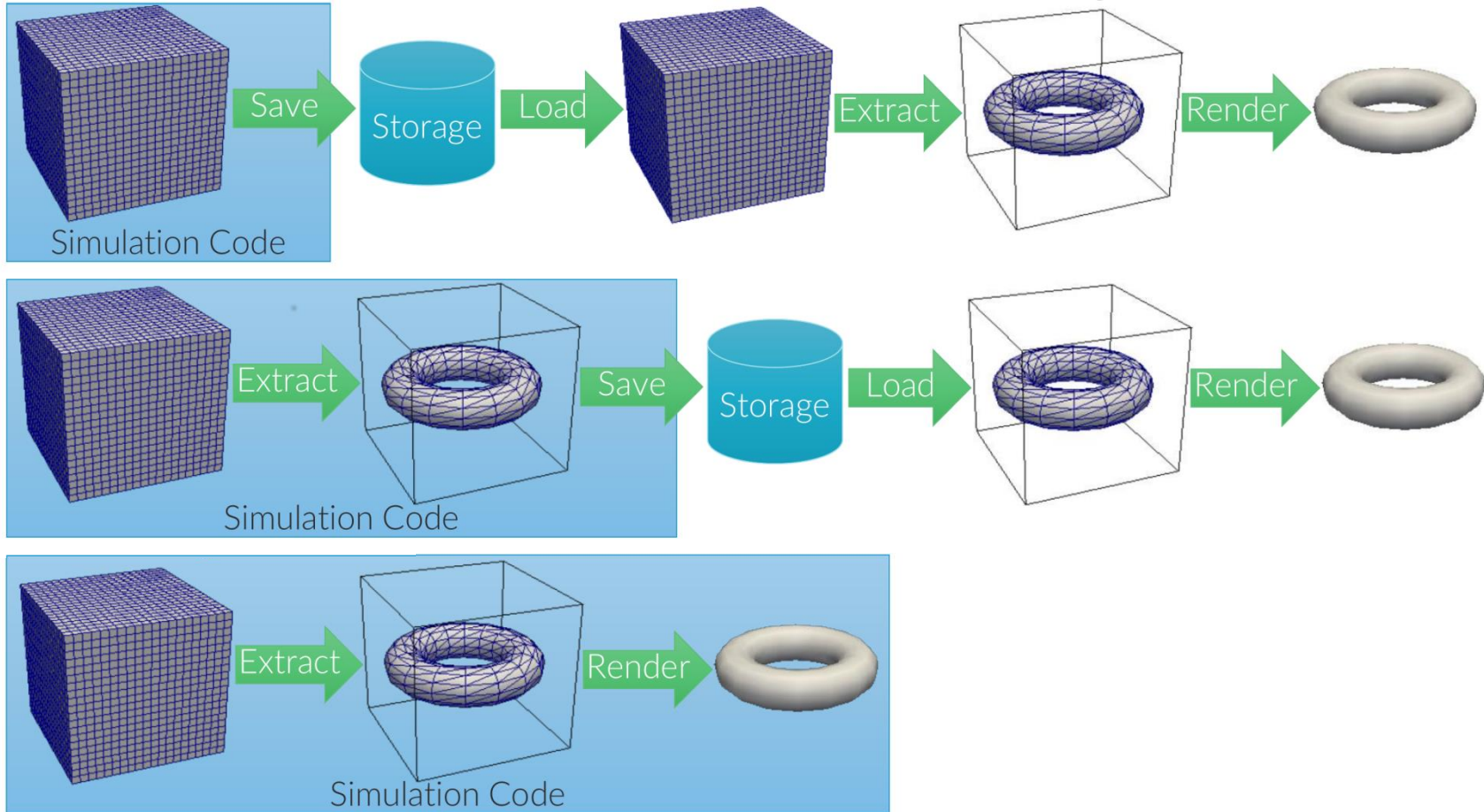
## In Situ Visualization (ParaView/Catalyst)



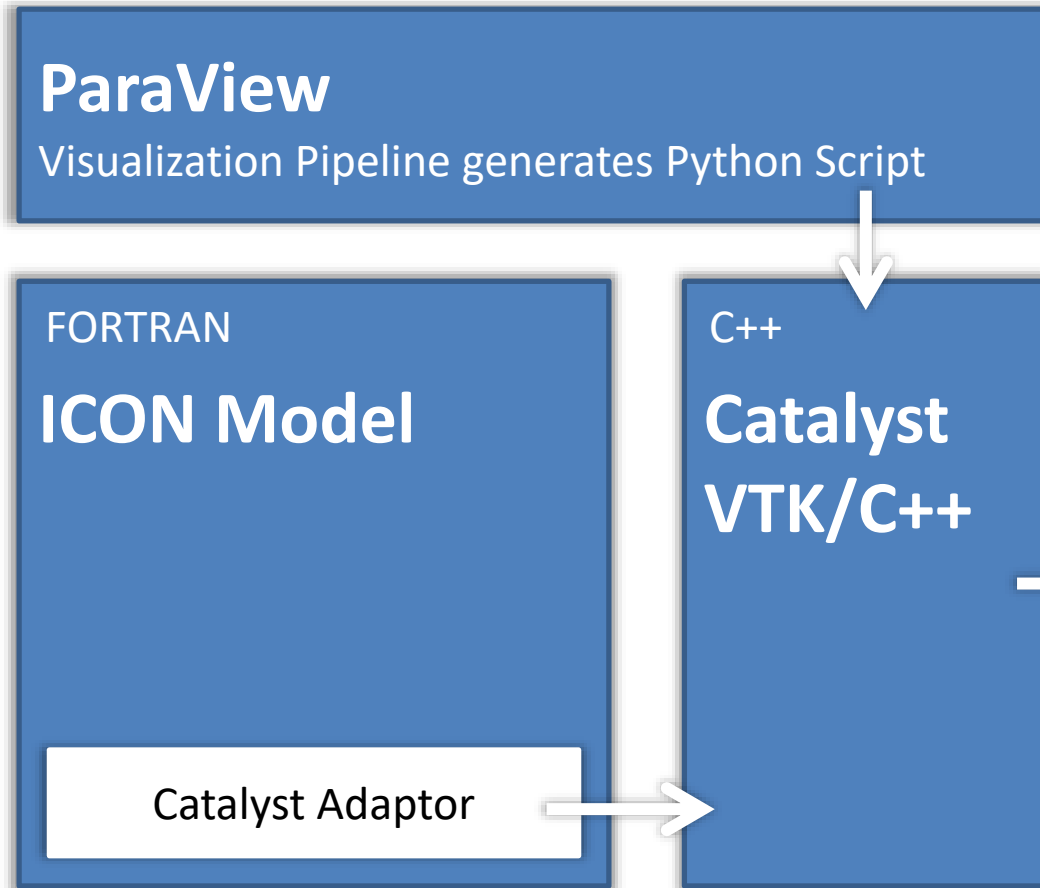
## Progressive Visualization (VAPOR)



# From Post Visualization to In-Situ



# ICON and Catalyst Adaptor



- Rendered images
- Cinema database
- Data reduction (par. I/O)
- Feature det./tracking (e.g. cloud classification)
- Live visualization
- Data decomp./comp.

# Advantages

- Much less I/O  
-> Simulation faster / less disk
- Preview of data
- In situ feature tracking
- Analyze extremely large simulation “output”
- Time to knowledge shorter

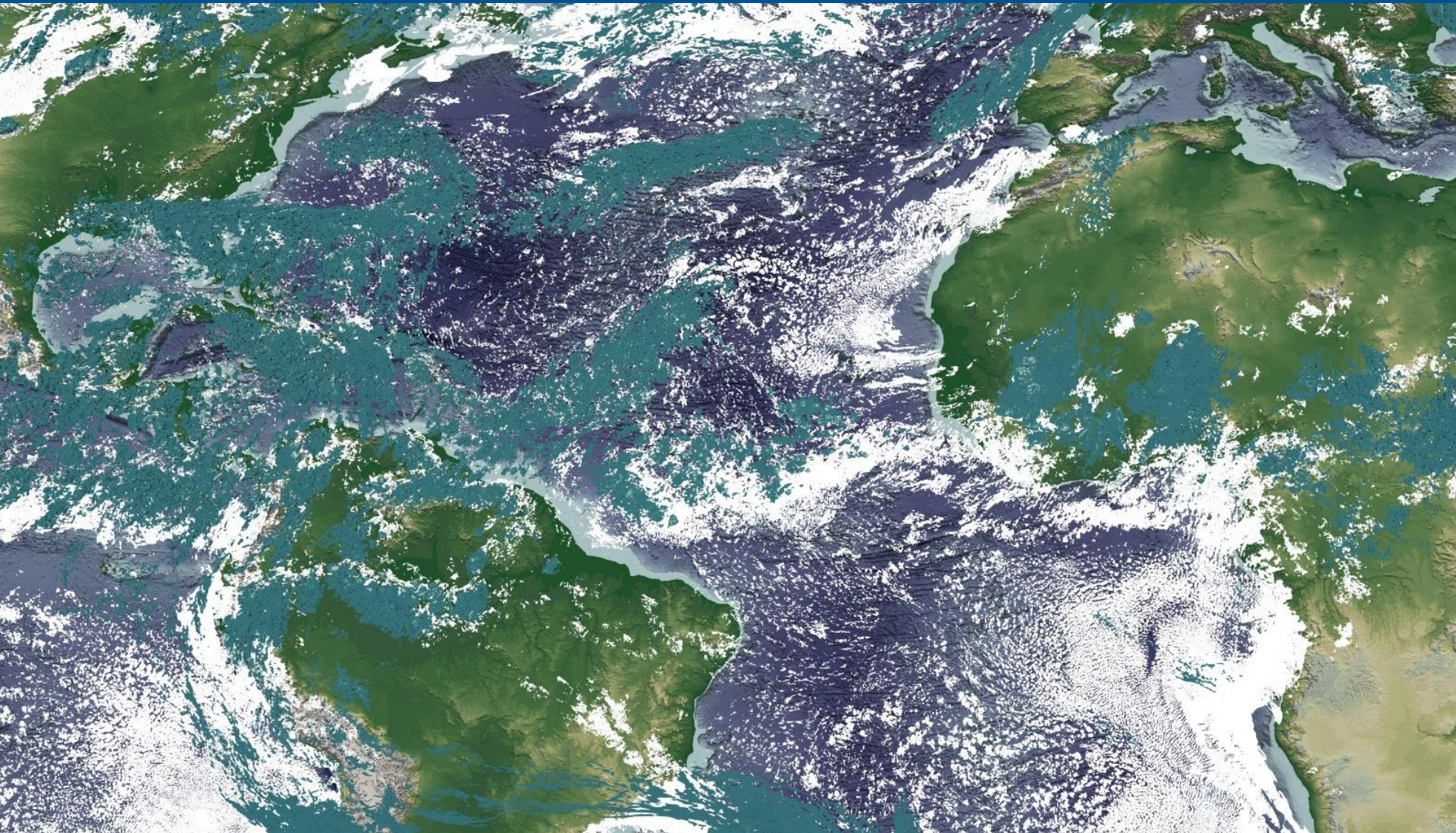
# Drawbacks

- Additional resources required
- A priori knowledge needed
- Need to run sim/vis again for new analysis/visualization
- Workflow complexity increases
- Statistical analysis more complex

# Generating a Catalyst Script

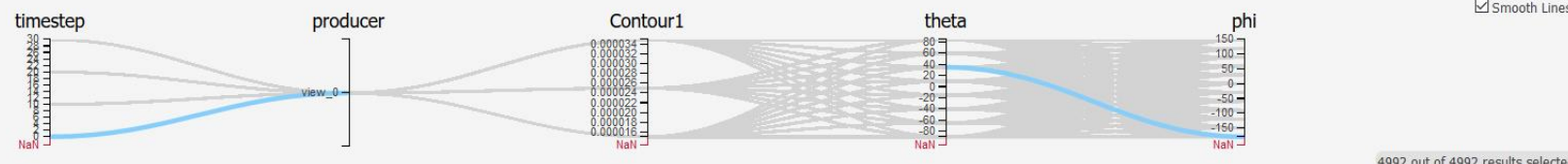
The screenshot shows the ParaView 5.6.0-RC2 64-bit interface. The main window displays a 3D visualization of a catalyst structure, with a pinkish-purple surface and a blue base. The Catalyst Export Inspector dialog box is open, showing the following settings:

- Data Extracts:** Threshold1, XMLPUnstructuredGridWri
- Image Extracts:** RenderView1, PNG image (\*.png)
- Global Settings:**
  - Enable Live Connections
  - Live Frequency: 1
  - Root Directory: bn/experiments/atm\_icoles\_giraffe/
  - File Padding: 0
  - Request Specific Arrays
  - Write Start: 0
  - Force First Output
  - Rescale to Data Range
  - Save Cinema D Table



# Cinema:Explorer

Select Database: amip Load



4992 out of 4992 results selected

Image Spread

Scatter Plot

Line Chart

Results Per Page: 25  
Sort By: timestep  
Reverse Sort Order:   
Group equal values:

Image Size: 150px

Index: 5  
timestep: 0.000000e+00  
producer: view\_0  
Contour1: undefined  
theta: 35  
phi: -180  
FILE: cinema/R2B10/0.000000e+00/-180/35.png

1 11 > > |  
1 / 200



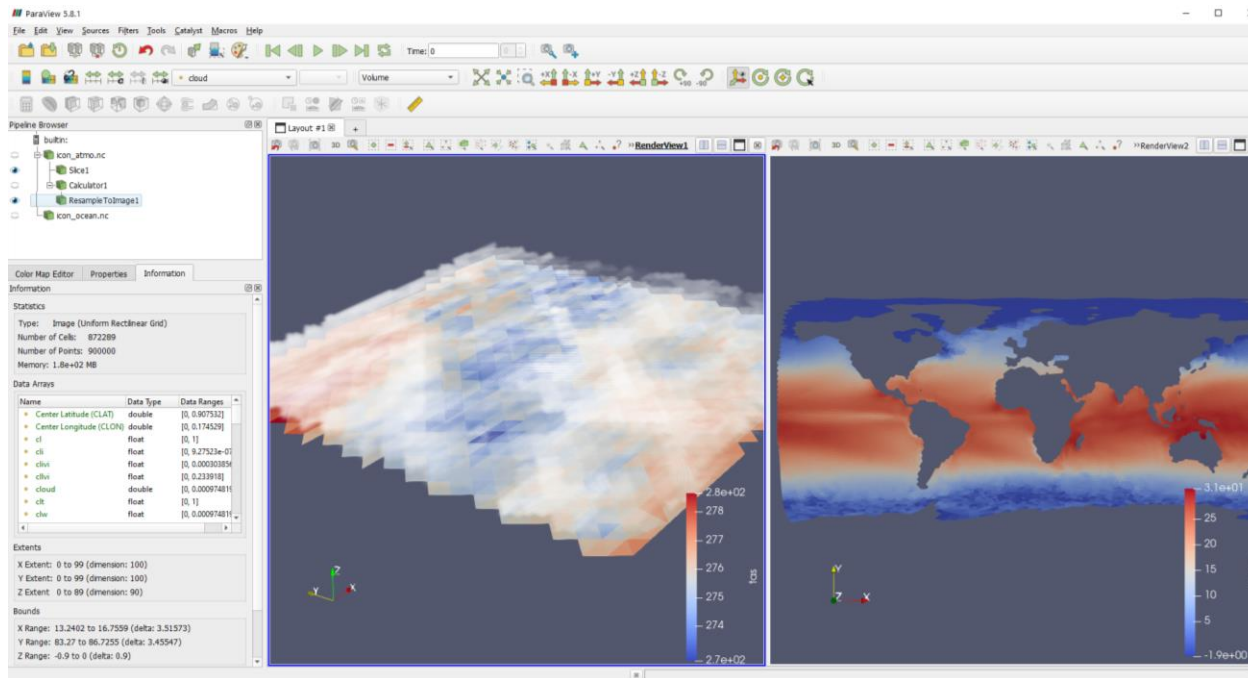
# Implementation & Status

- Started refactoring other in-situ code -> too complex
- Started fresh -> few hundred lines in FORTRAN and C++ with minimal changes to ICON
- Zero copy arrays FORTRAN -> C++
- Tightly coupled (in line) w/ even number of sim/vis processes
- Prototype available on Mistral for ICON
- Development of workflows

# Timings R2B10 – 2.5km global / 540 nodes

name	# calls	t_min	min r	t_avg	t_max	max r	total min (s)	total min r	total max (s)	total max rank
<b>total</b>	4305	06m48s	[6]	<b>06m48s</b>	48s	[3919]	408.010	[6]	<b>408.027</b>	[3919]
L wrt_output	8610	0.00778s	[17]		90s	[3239]	23.707	[14]		[2838]
L integrate_nh	344400	3.9458s	[34]		784s	[256]	347.016	[34]		[0]
L nh_solve	1722000	0.29028s			31s	[216]	156.504	[20]		[47]
L nh_hdiff	344400	0.09548s	[13]		944s	[420]	8.426	[21]		[1852]
L physics	344400	0.53099s	[4]	<b>0.02430s</b>	728s	[2598]	57.132	[4]	<b>2.037</b>	[2831]
....										
L insitu_set_var	344400	0.01999s		<b>0.06853s</b>	760s	[221]	1.663		<b>10.067</b>	[126]
L insitu_do_work	340095	0.00014s	[10]	<b>1.6174s</b>	341s	[0]	5.312	[23]	<b>2.033</b>	[0]
L insitu_do_work1st	4305	1.5387s	[22]		325s	[0]	1.539	[22]		[0]
....										
model_init	12915	1.5042s	[17]	<b>01m11s</b>	01s	[1672]	214.388	[19]	<b>215.458</b>	[885]
L insitu_init	4305	4.9177s	[19]	<b>6.1077s</b>	381s	[4164]	4.918	[19]	<b>6.388</b>	[4164]

# Hands-on Examples with ParaView



<https://visualisation.gitlab-pages.dkrz.de/documentation>  
[https://swiftbrowser.dkrz.de/tcl\\_s/hoLF5lcPYXhvov](https://swiftbrowser.dkrz.de/tcl_s/hoLF5lcPYXhvov)

- [www.paraview.org](http://www.paraview.org)
- [discourse.paraview.org](https://discourse.paraview.org)
- [www.paraview.org/Wiki/The\\_ParaView\\_Tutorial](http://www.paraview.org/Wiki/The_ParaView_Tutorial)
- [www.dkrz.de/up/services/analysis/visualization/sw/paraview](http://www.dkrz.de/up/services/analysis/visualization/sw/paraview)

esiwace  
CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER  
AND CLIMATE IN EUROPE



The projects ESIWACE and ESIWACE2 have received funding from the European Union's Horizon 2020 research and innovation program under grant agreements No 675191 and No 823988.

[www.esiwace.eu](http://www.esiwace.eu)